NextGen
Trajectory-Based Operations
Status Update

Environmental Working Group
Operations Standing Committee

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Outline

- Key Technical Concepts in TBO
- Current TBO Activities
  – RTCA ATMAC Trajectory Operations Working Group
  – FAA NextGen Mid-Term Concept of Operations
  – JPDO TBO Study Team

WARNING!

Most charts in this briefing copied from others

The Transformation to NextGen

Our
Mission

Procedural Based Control:
Control on Where We Think the Aircraft Is

Landmark Navigation
Radio Beacons
Position Reports

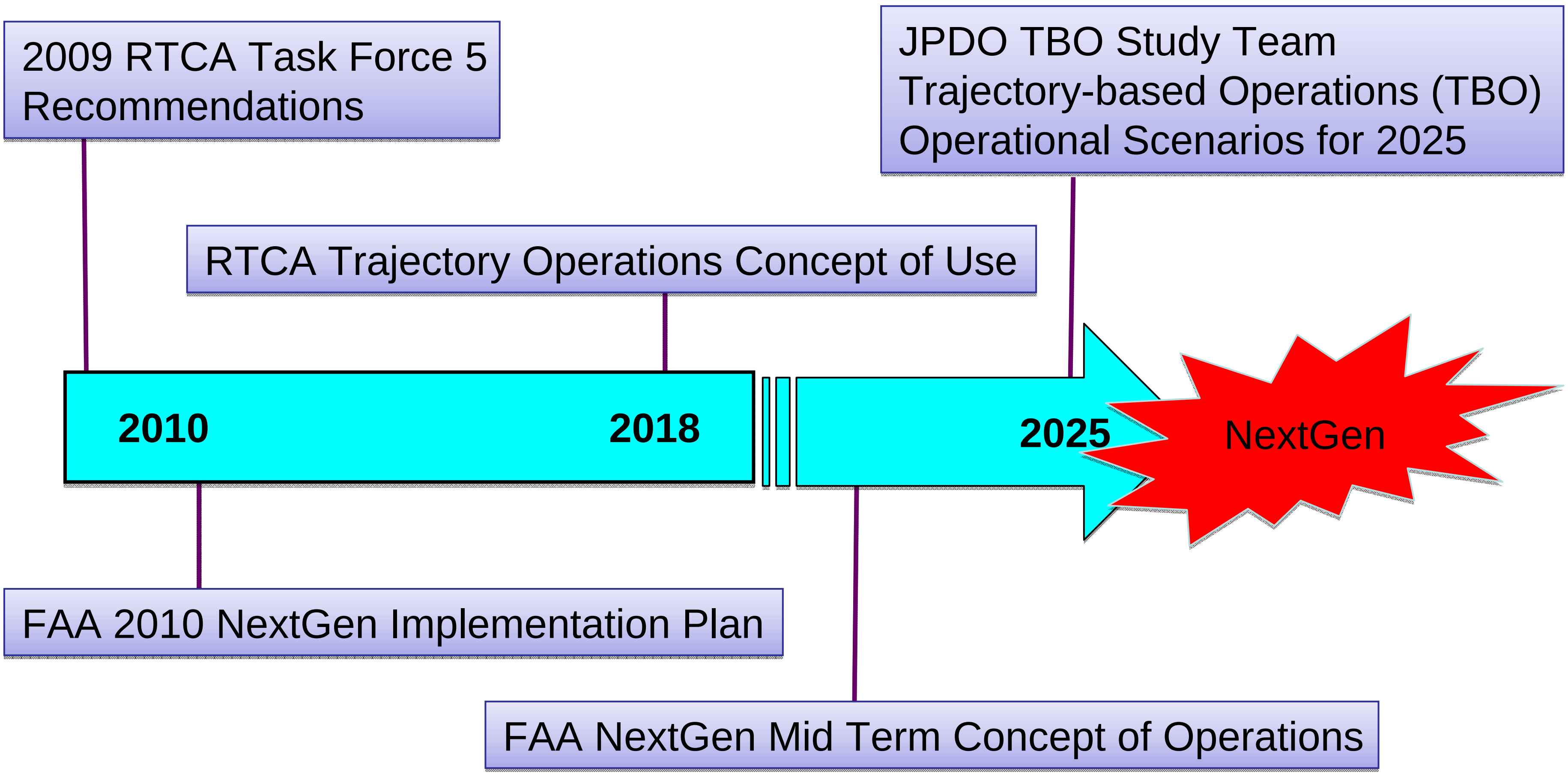
Surveillance Based Control:
Control on Where We Know the Aircraft Is

VOR/DME
RADAR

Trajectory Based Control:
Control on Where We Know the Aircraft Will Be

RNP
ADS-B
DataComm

The Transformation to NextGen
TBO in documents…



Definitions (1)

Trajectory Operations – is the concept of an air traffic management system in which every aircraft that is operating in or managed by the system is represented by a four-dimensional trajectory (4DT). Every managed aircraft known to the system has a 4DT either provided by the user or derived from a flight plan or type of operation. Trajectory operations, or TOps, represent a mid-term implementation strategy to gain capacity and efficiency.

(FAA Starting Definition into RTCA)

Definitions (2)

Trajectory-based Operations – extends TOps and provides separation, sequencing, merging and spacing of flights based on a combination of their current and future positions. TBO operates gate-to-gate, extending benefits to all phases of flight operations. TBO uses the 4DT to both strategically manage and tactically control surface and airborne operations. Aircraft are handled by their trajectory. (TBO Study Team Definition)

Definitions (3)

Closed trajectory – the pilot, the FMS, the controller and the automation all have the same closed path

Open trajectory when the aircraft is flying at pilots discretion (may be with constraints) or on a controller open clearance e.g. “vector for traffic, turn 20 degrees left”

Automation systems may “try” to close trajectories as part of the projection forward – but trajectories are not closed until explicitly closed by instruction or implicitly closed by rejoining

Key Mid-Term Concepts

All (controlled) aircraft have a 4D trajectory

- Uncertainty is higher where ANSP must predict trajectory based only on flight plan
- Performance varies by aircraft & system (eg. RNP)

Begins with published routes/procedures and ground automation improvements

Longer term:

- Maintain closed trajectories whenever possible: consistent in aircraft and ANSP, 4D for entire operation
- Trajectory can include ‘windows’ with built-in flexibility
- Degree of aircraft involvement can vary based on user needs & investment

Trajectory Operations

Management by Trajectory blends separation and flow

Surveillance supports system-aided conformance monitoring, conflict prediction

Structure very robust and may be based on dynamic assignment of trajectories

Automation provides conflict resolution advisories as trajectory changes

- –Inclusion of automation in the primary activity increases the percentage of closed trajectories
- –With data comm – controller preference is for automation supported clearances, closed trajectories become the norm

Trajectory Operations - 2

Flow management based on trajectories

- Tailored to individual flights
  - Become trial plans for controllers

- Time based metering includes proposed trajectory clearances
  - Controller reviews, issues and monitors
  - Limited in the near-term by voice communication limitation

Trajectories carried in flight object with flight plan

- Trajectory projection includes all known constraints such as TMI’s, SUA etc.

Phases of Trajectory Operations

Pre-Negotiation	Negotiation	Agreement	Execution
System-Wide Information Management		Data Commun-ication	ADS-B, Data Comm.

ADS-B: Conformance Monitoring,
Aircraft-to-Aircraft Intent

DataComm: Aircraft-to-Ground Intent

Trajectory Clearances take many forms

Trajectories with ETA

- Most common form – for the unequipped it is the ground derived ETA; for the FMS equipped may be provided by aircraft

Trajectories with RTA

- Aircraft and ground agree on a trajectory with an RTA – aircraft will fly to "make" time

Relative spacing

- Aircraft and ground agree on trajectory path – time component is based on time or distance spacing with a preceding aircraft

All three can and will exist based on operational need

– for instance a relative spacing trajectory may be in relationship to a preceding aircraft with either RTA or ETA trajectory agreement

RNAV/RNP

The backbone of trajectory operations – basis for the expanded airspace separation structure

Allows for a dynamic structure – the trajectory agreed to with solid performance expectations

- Evolutions to be worked
  - Can a trajectory clearance off a published procedure/route have an RNP value?
  - How do flexibility windows relate to RNAV or RNP?

Data Communications

Provides the link from controllers' tools to fight deck

- In current environment tools become a supplemental aid
  - Controller has to formulate verbal message and exchange
  - Complexity of solution limited by verbal bandwidth
- In a data communication environment tools become part of primary task to formulate message
  - Graphically represented solution on both ends

Provide path for periodic update of aircraft intent

Provides dynamic RNAV/RNP routes removing dependence on aircraft database

Allows strategic communications with ATM from other than tactical controller

Changes the tactical role of Flight Operations Center

ADS-B

- Without ADS-B only have two trajectory forms – ETA and RTA
- Relative spacing provides the middle ground
  - ETA - level of predictably will either
    - Increase spacing to buffer for lower predictability
    - Lead to intervention such as today's TMA which leads to increased spacing in high demand
  - RTA – less fuel and emissions friendly
    - Depends heavily on the aircraft's knowledge of winds
    - Less predictability along path – aircraft fly to the end goal
    - Less robust to perturbation – i.e. aircraft that do not make RTA
  - Relative spacing provides increased certainty of aggregate behavior
- ADS-B provides all the other good things – expanded coverage for the operation, supports procedures/routing with lower separation reqts. *(goal)*

Equipage Challenges and Issues

Mixed capability operations: To what extent can ANSP personnel manage operations and differentiated services when aircraft have different trajectory management capabilities?

How will equipage objectives be achieved when benefits depend on a significant percentage of aircraft equipage?

What are the tradeoffs among costs, benefits, and risks for different levels of capability for both aircraft and ground systems?

Constraints/Reality

Technological Constraints

Certification of highly automated systems for the "no-human hands" case

Reversing non-optimal spectrum decisions

Ownership of operational data

Major Policy Decisions

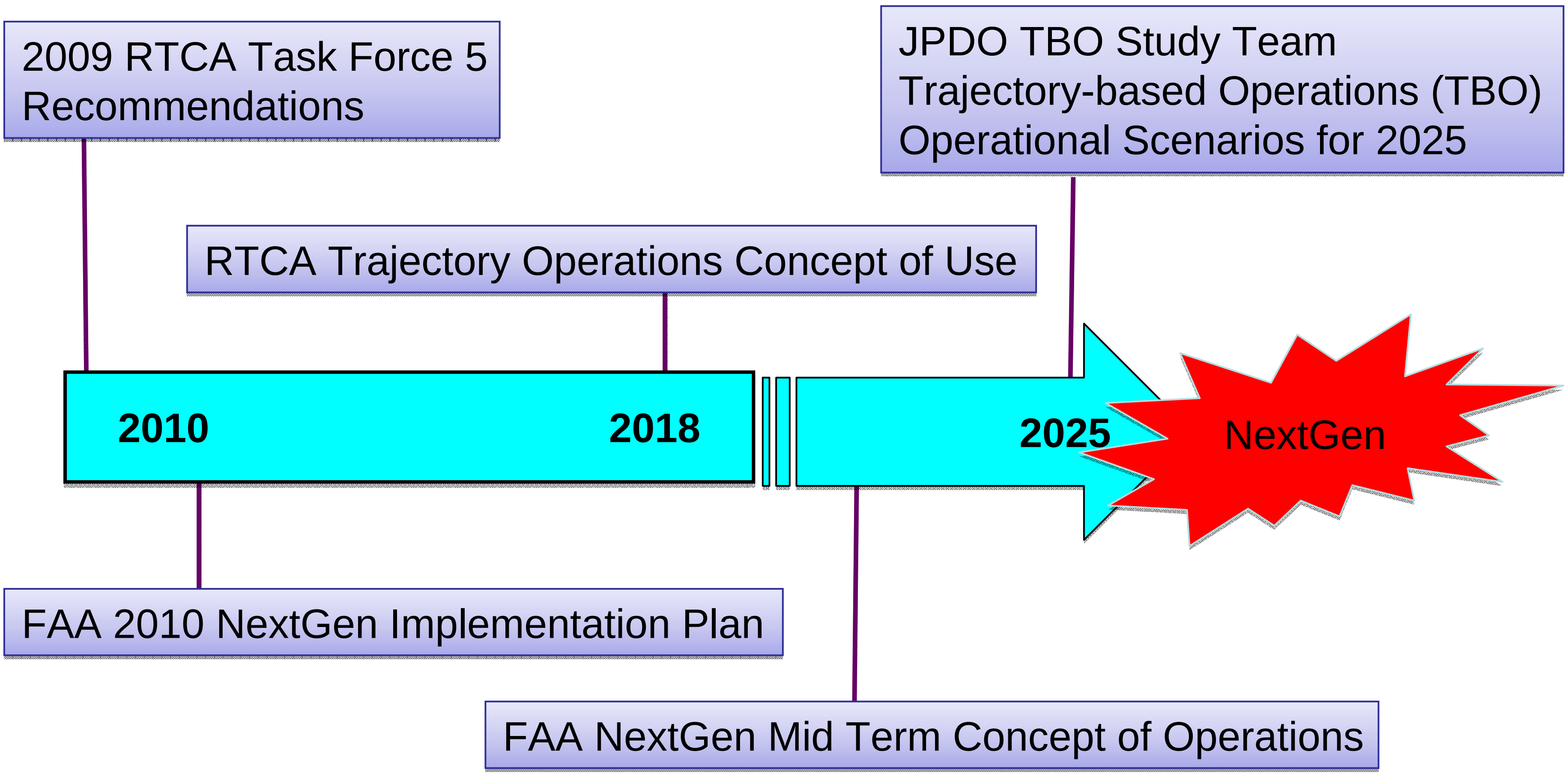
Airspace "rules" for higher performance operations

Roles within ATC – can we shift?

Environmental trading

Controller deskilling and how to deal with it

The Transformation to NextGen
TBO in documents…



Concept of Use for Trajectory Operations: Scope of Work

1. Describe and frame the types of trajectories envisaged through the mid-term (now through 2018),

2. Consider and document any potential evolution of trajectory-based operations from 2018 through 2025,

3. Identify the non-technical capabilities, e.g., ability for an aircraft to adhere to an RTA at an arrival point, ability of ATC automation system to calculate weather reroutes for multiple aircraft and uplink, etc.) required for aircraft systems and ground automation systems,

4. Identify any areas of regulatory change that may be needed to support the concept.

FAA NextGen Mid-Term ConOps

The Mid-Term

Is a steppingstone in a transition from the current National Airspace System (NAS) to the NextGen envisioned in the JPDO NextGen Concept of Operations (Conops)

Represents a timeframe that coincides with initial implementation of several key capabilities

The following enabling technologies are assumed:

- Data communications
- Digital voice switching
- Performance-based navigation
- Network-enabled information sharing
- Satellite-based surveillance
- Integration of weather into decision-making
- Collaborative air traffic management

Mid-Term ConOps (cont.)

Objectives

Integrate Mid-Term NextGen Operational Improvements (OIs) into a cohesive story

Focus on gate-to-gate concepts from air traffic management perspective

Generate discussion with stakeholders

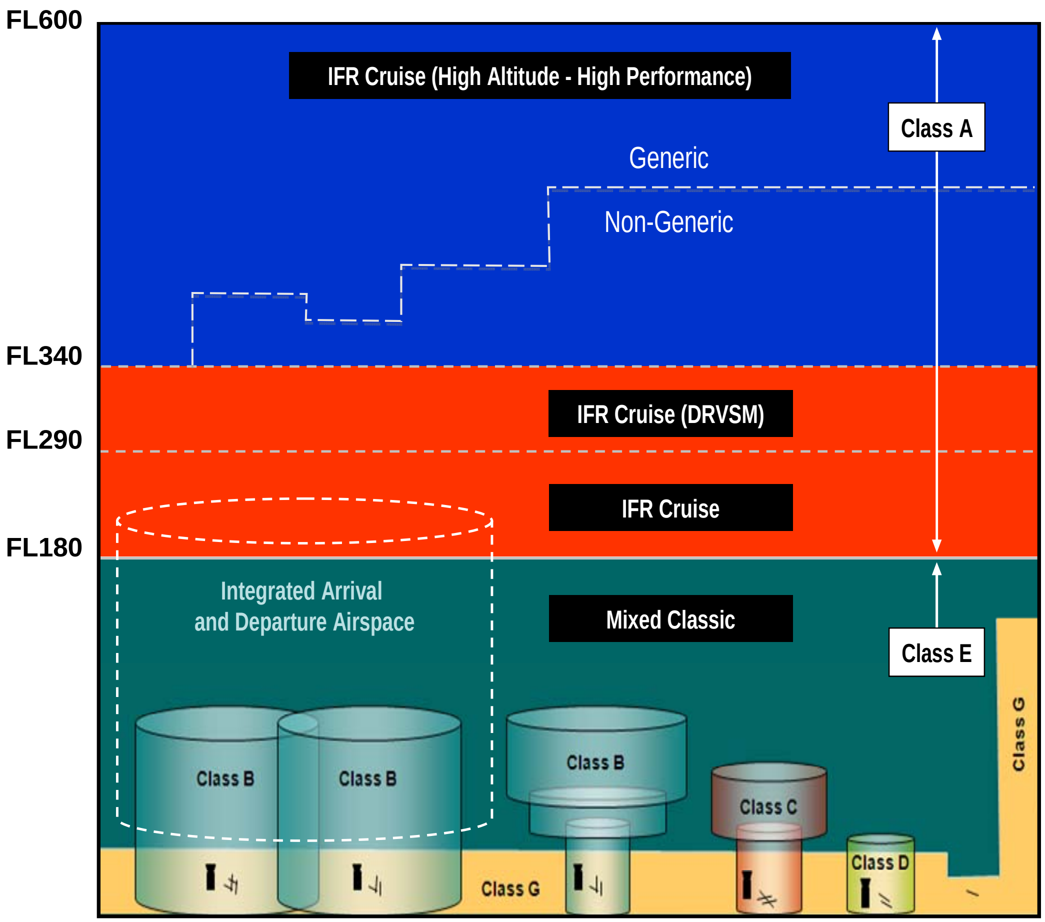
Identify areas and issues for research

Be iterative in nature

Do NOT identify technical solutions

Lay the groundwork for system engineering activities (e.g., functional analysis, requirements allocation)

Mid-Term Conops: Overview



Operating Environment

- Airspace Structure
- Flexible Airspace Management
- Automation
- Surveillance
- Communications
- Collaborative Decision Making
- Human Systems Integration

Airspace classifications (A-E) remain the same as today. Performance requirements within, however, change.

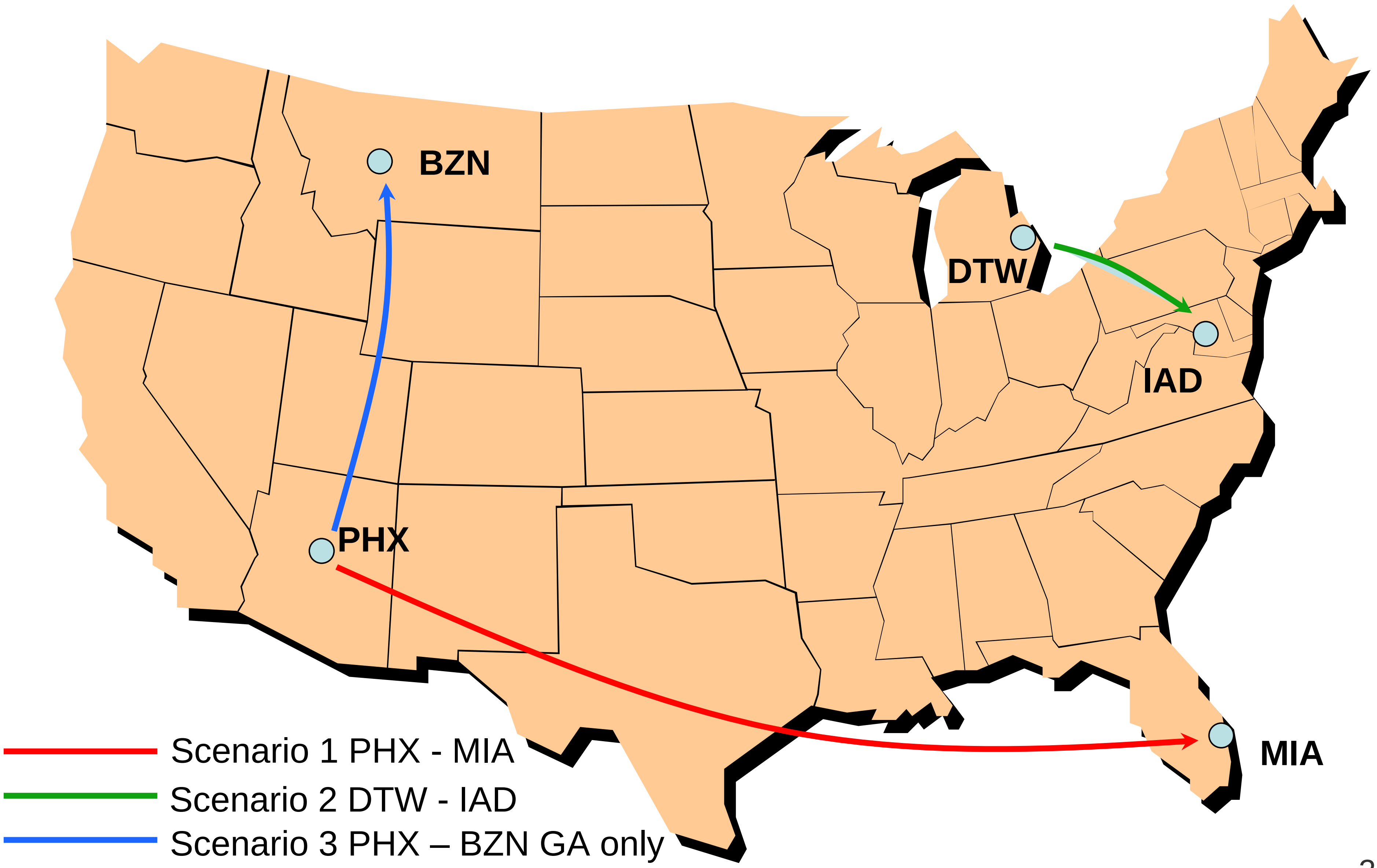
JPDO TBO Study Team: Objectives

- Develop operational scenarios describing trajectory-based operations
- Develop and agree on Use Case steps for use in modifying the Enterprise Architecture and Avionics Roadmaps
- Identify a set of findings and recommendations to guide transition from Trajectory Operations to Trajectory-based Operations

TBO Scenarios and Use Cases

- **Who** – Dispatch, flight crew, ANSP
- **What** – Scenarios, Use Cases, Findings and Recommendations
- **When** – 2018-2025
- **Where** – Throughout the NAS and Off-shore
- **Why** – To drive consensus on TBO, provide information for architectural analysis, identify recommended changes to the Integrated Work Plan and the OIs
- **How** – TBO Study Team – leveraging proven processes
  - NASA NRA on Introducing new aircraft to NextGen
  - I-CNS Raytheon Team work with NextGen Institute
  - Positioning, Navigation and Timing GNSS backup

TBO Storyboard Operational Scenarios



Sources of Information

JPDO NextGen Documents

http://jpe.jpdo.gov/ (login required)

FAA Enterprise Architecture Roadmaps

https://nasea.faa.gov/

RTCA Task Force 5 Recommendations

http://www.faa.gov/about/initiatives/.../nextgen_progress_report.pdf

FAA Response to Task Force 5

http://www.faa.gov/.../FAA_**TASKFORCE**_RESPONSE_1-31-2010.pdf

2010 NextGen Implementation Plan

http://www.faa.gov/about/initiatives/**nextgen**/media/NGIP_3-**2010**.pdf